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ABSTRACT

The 135-hour quinmester course covers study of basic radio circuits as applied to vacuum tube radios in six blocks of instruction: orientation; AM receivers with tubes; no signal, audio failure; distortion; weak, noisy signals; and a post-test. Each block is subdivided into several units, and block objectives are outlined. Completion of AC Circuits and Active Devices (9785.02) is a prerequisite. The course emphasizes diagnostic skills and those manipulative skills having to do with use of instruments and tools with the object of repairing items in a production shop environment. An answer key is provided for the two-part post-test, and a bibliography lists basic and supplementary references and films. (AG)

ED 097472

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AUTHORIZED COURSE OF INSTRUCTION FOR THE QUINMESTER PROGRAM

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Course Outline
RADIO AND TELEVISION SERVICE - INTERMEDIATE - 9785
(Basic Radio Circuits and Vacuum Tube AM Troubleshooting)
Department 48 - Quin 9785.03

CE 002 238

DADE COUNTY PUBLIC SCHOOLS

DIVISION OF INSTRUCTION • 1973

ED097472

D A D E C O U N T Y P U B L I C S C H O O L S

1450 NORTHEAST SECOND AVENUE

M I A M I, F L O R I D A 33132

Course Outline

RADIO AND TELEVISION SERVICE - INTERMEDIATE - 9785
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Department 48 - Quin 9785.03

county office of

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Dade County Public Schools
Miami, Florida 33132

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Miami, Florida 33132

Course Description

9785	48	9785.03	Basic Radio Circuits and Vacuum Tube AM Troubleshooting
State Category Number	County Dept. Number	County Course Number	Course Title

This is a basic quinmester course which covers study of basic radio circuits as applied to vacuum tube radios. Troubleshooting techniques and diagnostic methods are applied to live production work following development of skills through laboratory experiments and construction projects. This is a two or three quinmester credit course of one hundred thirty five hours duration.

Indicators of Success: Prior to entering into this course the student shall have completed Course 9785.02, A. C. Circuits and Active Devices, passing the quinmester post-test.

Clock Hours: 135

PREFACE

The following quinmester course is required in the Radio and Television Service Curriculum. Mastery of the skills in A. C. Circuits and Active Devices (9785.02) is required for entry into this study of circuits and troubleshooting.

This outline consists of six blocks of instruction of which are subdivided into several units each. This course is 135 hours in length.

Although the usual methods of instruction are employed there is emphasis on diagnostic skills and those manipulative skills having to do with use of instruments and tools with the object of repairing items in a production shop environment.

This outline was developed through the cooperative efforts of the instructional and supervisory personnel, the Quinmester Advisory Committee, and the Vocational Curriculum Materials Service, and has been approved by the Dade County Vocational Curriculum Committee.

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with Suggested Hourly Breakdown

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GOALS

The student must be able to demonstrate:

1. Knowledge of school and classroom rules of procedure, safe handling of tools and equipment, organization and management of the classroom.

2. Understanding of the requisites of filling an entry level job, and employment opportunities in his field.

3. Knowledge of basic radio theory and its application to construction and repair of vacuum tube radios.

4. Knowledge of current measurement in vacuum tube radios and its relation to distribution of voltages in radio circuits.

5. Knowledge and skill in signal injection and signal tracing as diagnostic tools.

6. Skill in successfully repairing common troubles in radio circuits.

7. Recognition of the causes of distortion and unstable signal conditions.

8. Ability to satisfactorily complete the quinmester post-test.

SPECIFIC BLOCK OBJECTIVES

BLOCK I - ORIENTATION

The student must be able to:

1. State what will be expected of him in meeting the standards of the course, taking tests and performance of manipulative operations.
2. Explain policies regarding attendance, safety regulations and shop management.
3. Discuss job opportunities and the qualifications for meeting these opportunities in entry level employment.
4. Demonstrate familiarity with the use of the text by locating topics in the index and by use of the glossary.

BLOCK II - AM RECEIVERS WITH TUBES

The student must be able to:

1. Explain the several types of power supplies and trace their circuits in live chassis.
2. Account for receivers being dead in terms of open circuits and short circuits.
3. Explain the function of the various types of vacuum tube amplifiers, tracing the signal path through them.
4. Explain the function of the common oscillator circuits employed in radios and be able to determine with use of appropriate instruments that the circuits are oscillating when in use.
5. Explain the function of IF amplifiers and be able to trace the IF signal in active radios.
6. Explain the principle of AM detection and its application to obtaining the audio signal and the AVC voltage.

BLOCK III - NO SIGNALS, AUDIO FAILURE

The student must be able to:

1. Using signal trace and/or oscilloscope, trace RF, IF and audio signals through the operating radio.
2. In a safe manner, use a finger tip to touch live audio amplifier circuits to determine if they are able to amplify.
3. Use a screw driver or other metallic object to momentarily short circuit terminals to listen for the click of a live circuit.
4. Use his own sensory perception to learn facts about abnormal conditions in an operating radio.
5. Use multimeters and vacuum tube voltmeters for reading of voltages and resistances.
6. Demonstrate systematic application of tests and measurements to reach a diagnosis of trouble.

BLOCK IV - DISTORTION

The student must be able to:

1. Identify types of hum sounds emanating from a live radio.
2. Locate and eliminate a cause of motorboating in a live circuit.
3. Identify clipped audio by its sound and by using appropriate instruments.

BLOCK V - WEAK, NOISY SIGNALS

The student must be able to:

1. Adjust alignment and tracking of a superheterodyne radio.
2. Locate and repair faulty antennae.
3. Discuss sources of man-made noise with regard to faulty reception.
4. Discuss radio propagation phenomena.

BLOCK VI - QUINMESTER POST-TEST

The student must be able to:

1. Satisfactorily complete the quinmester post-test.

Course Outline

RADIO AND TELEVISION SERVICE - INTERMEDIATE - 9785
(Basic Radio Circuits and Vacuum Tube AM Troubleshooting)

Department 48 - Quin 9785.03

I. ORIENTATION

A. Objectives of the Course
   1. Standards for performance of assigned work
   2. Methods of evaluation:
      a. Paper and pencil tests
      b. Oral responses
      c. Manipulative skill performance
      d. Troubleshooting and repair work
   3. Teaching methods
      a. Lectures
      b. Demonstrations
      c. Information and job sheets
      d. Experiments
      e. Projects
      f. Production work

B. Student Responsibilities:
   1. School policies relative to absences
   2. Safety regulations
   3. Work regulations
      a. Appropriate dress
      b. Care of hand tools
      c. Use and care of equipment
      d. Materials and supplies
      e. Means of reporting lost equipment
      f. Means of reporting inoperative equipment
      g. Production shop policies
      h. Housekeeping

C. Student Benefits
   1. Opportunities for employment
      a. Scope of the trade
      b. Job availability
      c. Remuneration
      d. Personal project construction
      e. Enjoyment of radio as a hobby
   2. Enrichment

D. Introduction to the Text
   1. Overview of chapter headings
   2. Bibliography
   3. Glossary
   4. Use of text with assignment sheets
   5. Planning experiments

II. AM RECEIVERS WITH TUBES

A. The Power Supply
   1. Half-wave
   2. Full-wave
   3. Doublers
   4. Bridge types

B. Dead Receiver
   1. Open circuits
   2. Short circuits

C. The Audio Stages
   1. The output stage
   2. The audio driver
   3. Push-pull output

D. The Oscillator-Mixer Stage
   1. Common oscillators
   2. Heterodyne principle
   3. The mixer

E. The IF Amplifier

F. The Detector Circuit
   1. The diode detector
   2. AVC
   3. Combination circuits

III. NO SIGNALS, AUDIO FAILURE

A. Signal Tracing
   1. Using the signal tracer
   2. Using the oscilloscope

B. Signal Injection
   1. The ever-ready finger
   2. Click tests

C. No-Cost Instruments
   1. Sniffing abnormal odors
   2. Feeling abnormal temperature
   3. Hearing abnormal sounds
   4. Seeing abnormal colors

D. Voltage Measurements
   1. Tube-element voltage testing
   2. Checking voltage drop of resistors and transformers.
   3. Resistance measurements
      a. In-circuit
      b. Out-of-circuit

III. NO SIGNALS, AUDIO FAILURE (Contd.)

E. Systematic Application of Tests and Measurements
   1. Progressing from output to input
   2. Selection of appropriate tests
   3. Tracing toward B+

IV. DISTORTION

A. Hum
   1. Identification of frequency
   2. Hum of power supply origin
   3. Open grid hum
   4. Tunable hum

B. Motorboating
   1. Failure of decoupling filter
   2. Inductive feedback
   3. Capacitive feedback

C. Clipped Audio
   1. Voltage measurements
   2. Resistance measurements
   3. Dragging speaker coil

V. WEAK, NOISY SIGNALS

A. Poor Tracking
   1. Adjustment of trimmer capacitor
   2. Adjustment of oscillator core
   3. IF transformer alignment

B. Antenna Problems
   1. Open antenna connection
   2. Grounded antenna

C. Man-Made Noises
   1. Flourescent fixtures
   2. Electric appliances
   3. Arcing high tension circuits

D. Natural Phenomena
   1. Antenna Directivity
   2. Seasonal changes in reception
   3. Causes of fading

VI. QUINMESTER POST-TEST

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A P P E N D I X

Quinmester Post-Test Samples

Quinmester Post-Test

Name _____ Date _____ Score ____

Part-One

Multiple-Choice Test Items

Each statement needs a word, a figure, or a phrase to make it correct. Only one of the choices listed is correct. Place the letter of the choice you make in the space provided to the left of the statement.

____ 1. The point of exit of an electron into the vacuum of a diode tube is called the:

a. Plate
b. Cathode
c. Emitter
d. Indirectly heated cathode

____ 2. Positive electrical charges are called:

a. Holes
b. Electrons
c. Protons
d. Neutrons

____ 3. The three elements of a triode tube are:

a. Cathode, filament and plate
b. Filament, grid and plate
c. Cathode, grid, and plate
d. Cathode, filament and grid

____ 4. The closer the control grid is to the plate

a. The more control it will have on electron flow.
b. The less control it will have on electron flow.
c. The higher the MU.
d. a and c above.

____ 5. A pentode is a:

a. Two element tube
b. Three element tube
c. Four element tube
d. Five element tube

____ 6. Transconductance is a measure of:

a. The change in plate voltage for a given change in grid voltage.
b. The change in plate current for a given change in grid voltage.

c. The change in plate current for a given change in plate voltage.
d. The change in plate voltage for a given change in plate voltage.

___ 7. A diode rectifier:

a. Has an output only when two signals are present
b. Eliminates undesired portions of the signal
c. Changes A.C. to pulsating D.C.
d. Can be used to maintain a special voltage level

___ 8. A diode limiter:

a. Has an output only when two or more signals are present
b. Eliminates undesired portions of the signal
c. Changes A.C. to pulsating D.C.
d. Can be used to maintain a special voltage level

___ 9. A diode detector:

a. Passes only the positive half or the negative half of a signal
b. Eliminates undesired portions of the signal
c. Changes A.C. to pulsating D.C.
d. All of the above

___ 10. A plate voltage, plate current ($E_p I_p$) curve can be used to determine:

a. The amount of current which flows when a given amount of voltage is applied
b. The amount of voltage necessary to cause a given amount of current to flow
c. D.C. plate resistance
d. All of the above

___ 11. Feedback due to interelectrode capacitance is called:

a. Interelectrode feedback
b. Positive feedback
c. Negative feedback
d. Feedback voltage

___ 12. Feedback due to interelectrode capacitance:

a. Increased the signal
b. Decreases the signal
c. Is 180° out of phase with the input signal
d. b and c above

___ 13. The input voltage to a full-wave rectifier is 120 volts at 60 Hertz. The output frequency is:

a. 30 Hertz
b. 60 Hertz
c. 90 Hertz
d. 120 Hertz

___ 14. The components of a pi-section filter are:

a. Input capacitor, output capacitor, and a load
b. Input capacitor, choke, and output capacitor
c. Output capacitor, choke, and load
d. Input capacitor, choke, and load

___ 15. In a bridge rectifier circuit with adequate filtering the maximum voltage across any diode is approximately:

a. Half the transformer secondary voltage
b. One-fourth the transformer secondary voltage
c. Full transformer secondary voltage
d. Twice the transformer secondary voltage

___ 16. The maximum voltage across any diode in a full-wave rectifier is approximately:

a. Half the transformer secondary voltage
b. One-fourth the transformer secondary voltage
c. Full transformer secondary voltage
d. Twice the transformer secondary voltage

___ 17. The maximum voltage across the diode in a half-wave rectifier with adequate filtering is approximately:

a. One-fourth the transformer secondary voltage
b. Half the transformer secondary voltage
c. The transformer secondary voltage
d. Twice the transformer secondary voltage

___ 18. In a pi-section filter, if the choke should open, the voltage supplied to the load would:

a. Go to zero
b. Have excessive ripple
c. Decrease slightly
d. b and c above

___ 19. In a pi-section filter, if the output capacitor should open, the voltage supplied to the load would:

a. Go to zero
b. Have excessive ripple
c. Decrease
d. b and c above

___ 20. In a pi-section filter, if the input capacitor should short, the voltage supplied to the load would:

a. Go to zero
b. Have excessive ripple
c. Decrease
d. b and c above

___ 21. The output frequency of a bridge rectifier is:

a. Half the input frequency
b. The same as the input frequency
c. Twice the input frequency

___ 22. In an L-section filter, if the capacitor should open, the voltage supplied to the load would:

a. Go to zero
b. Have excessive ripple
c. Stay the same
d. Rise

___ 23. A class-A amplifier:

a. Is biased beyond cutoff
b. Is biased to cutoff
c. Conducts during 360° of the input cycle

___ 24. A vacuum tube biased at approximately cutoff would be operating:

a. Class A
b. Class B
c. Class C
d. Class D

___ 25. A class C amplifier is biased:

a. In center of the linear portion of the curve
b. At or near cutoff
c. 1.5 to 4 times cutoff
d. At zero

___ 26. When the negative bias of a tube is increased to a point where no plate current flows, the point is called:

a. The bias point
b. Saturation point
c. Cutoff point
d. Limiting point

___ 27. A load line drawn on the graph of the plate characteristic curves of a tube:

a. Shows the grid bias
b. Connects a point representing the plate supply voltage and a point representing plate current limited only by load resistance.

c. Represents various plate load resistances
d. Shows how much plate current will flow with various plate loads.

___ 28. Bias, obtained by placing a resistor in the cathode circuit to make the cathode positive with respect to the grid, is called:

a. Grid-leak bias
b. Cathode bias
c. Fixed bias
d. Resistor bias

___ 29. A cathode bypass capacitor is used to:

a. Increase the impedance of the cathode
b. Maintain a constant potential on the cathode
c. Increase electron emission
d. Improve the shape of the characteristic curve

___ 30. The three basic parts of an oscillator are:

a. A tank circuit, an amplifier, and a load
b. A tank circuit, a resonant circuit, and an amplifier
c. An amplifier, a resonant circuit, and a load
d. An amplifier, a tank circuit, and a feedback circuit

___ 31. The main difference between a shunt-fed Hartley oscillator and a Colpitts oscillator is:

a. The Hartley has a tapped coil in the tank and a Colpitts has a split capacitor
b. The Hartley has a split capacitor in the tank circuit and the Colpitts has a tapped coil
c. The Hartley uses negative feedback and the Colpitts uses positive feedback
d. The Hartley has a cathode bypass capacitor and the Colpitts has a grounded cathode

___ 32. The load resistance of an amplifier:

a. Controls the plate supply voltage
b. Controls the grid voltage signal
c. Has no effect on the gain of an amplifier
d. Has a marked effect on amplifier gain

___ 33. In a two-stage, RC-coupled amplifier, the gain of the first stage is 25 and the gain of the second stage is 40. The theoretical gain of the amplifier is:

a. 1000
b. 65
c. 15
d. 1.6

___ 34. In a two-stage, RC-coupled amplifier, the gain of each stage is 40. The overall gain of the amplifier is approximately:

a. 1600
b. 1332.8
c. 80
d. 160

___ 35. In an RC-coupled amplifier a defective plate load resistor changes in value from 470,000 ohms to more than 2 megohms the amplifier will:

a. Increase gain
b. Cease amplifying
c. Lose gain
d. Oscillate

___ 36. If a 47 picofarad capacitor which couples oscillator signal to the grid of a mixer tube loses most of its capacitance the radio will:

a. Operate as usual
b. Track at low frequency end of band
c. Track at high frequency end of band
d. Have a loud hum

___ 37. Signal tracing reveals that the mixer and IF stages of a radio are operating, but there is no output at the speaker. The fault is likely to be:

a. An open audio output transformer
b. An open plate load resistor
c. An open voice coil
d. All of above

___ 38. All B+ voltages of an amplifier are a small fraction of their normal value. The fault is likely to be:

a. A weak rectifier tube
b. A leaky electrolytic capacitor
c. An open decoupling resistor in the output stage
d. a and b above

___ 39. The oscillator grid voltage at the 12BE6 tube of a radio is approximately zero volts and stations cannot be tuned in. The fault is:

a. An open IF transformer secondary winding
b. An open antenna coil
c. An open oscillator coil
d. Antenna section of the tuning capacitor is shorted

___ 40. At low settings of the volume control of a radio the sound output at the speaker although weak is undistorted. At high settings of the volume control the sound is badly distorted. The fault is likely to be:

a. An open output transformer
b. An interelectrode short in the output tube
c. A leaky audio coupling capacitor
d. None of the above

___ 41. An audio amplifier hums loudly when the volume control is advanced to maximum setting. The fault is likely to be:

a. An open filter capacitor
b. An open filter choke
c. An open grid resistor in a low level stage
d. A rubbing voice coil in the speaker

___ 42. A radio has low sensitivity to all stations, although a signal injection at the volume control reveals that the audio amplifier is operating normally. The fault is likely to be:

a. A weak IF tube
b. IF transformer misaligned
c. A screen grid resistor greatly increased in resistance
d. All of the above

___ 43. A radio has weak output on all stations. Signal tracing discloses a normal signal up to the volume control. The fault is likely to be:

a. A weak audio amplifier tube
b. Low B+ voltage in the IF stages
c. Plate load resistor greatly increased in resistance
d. a and c above

___ 44. Voltage at the B+ side of a decoupling resistor is within normal range, but voltage at the load side is zero. The fault could be:

a. A short on the load side of the connection
b. A cold soldered connection
c. An open decoupling resistor
d. Any of the above

___ 45. On printed circuit boards, the most common problem with loss of voltage or signal is:

a. Short circuits
b. Misplaced components
c. Open connections

___ 46. A low value resistor placed in series with a rectifier diode:

a. Reduces voltage
b. Filters hum
c. Protects the diode from current surges
d. All of above

___ 47. Replacement parts should be selected for their:

a. Low cost
b. Exact physical match
c. Exact electrical match
d. b and c above

___ 48. An RC-coupled amplifier has zero output. Signal tracing reveals that there is normal signal at the plate of the driver and zero signal at the grid of the output tube. The most likely fault is:

a. An open plate load resistor
b. An open grid resistor
c. A shorted cathode bypass capacitor
d. An open coupling capacitor

___ 49. Transconductance is measured in units called:

a. Ohms
b. Mhos
c. Gm
d. Mu

___ 50. The space charge of a tube:

a. Is made up of emitted electrons
b. Is nearer the cathode than the plate
c. Repels electrons back toward the cathode
d. All of the above

Quinmester Post-Test

Name _____ Date _____ Score ____

Part-Two

Return Part-One of this test to the instructor when you have completed your answers. The instructor will issue to you along with this question sheet for Part-Two a copy of the textbook, Radio Service Training Manual. Use the book to refer to the figures around which the following test questions have been written.

Example: Refer to Figure 3-2, page 44. All questions under this caption will be derived from this particular figure. Now commence with the first question.

Refer to Figure 2-2 (B), page 15

1. What is the function of R2?

2. What should the minimum working voltage of C1 and C2 be?

3. What is the function of R3?

Refer to Figure 2-21, page 39

4. What voltage would be read by meter at the cathode of the 12BE6 if the cathode to ground winding of L2 were open?

5. Under the same condition as question 4, what symptom would the radio have?

6. Under the same condition as question 4, what would the voltage probably be at terminal 1 of the 12BE6?

7. If the plate voltage of the 12BE6 were found to be zero volts what part would be defective?

8. If the heater of the 35W4 is found open between terminals 4 and 6 which component of the radio would be at fault?

9. If none of the heaters of the radio operate and a voltage of 120 V A.C. is found between terminals 3 and 4 of V1 what is the defect?

10. If the audio output of the radio is distorted and the voltage at G1 of the 50C5 is positive what is the defect?

11. If an injected signal of 455 KHz is found at the plate of the 12BA6, but not at terminal number 5 of the 12AV6, what is the defect?

12. If the 50C5 tube checks normal in a tube tester, but the cathode resistor is burned; which component is responsible?

13. If the plate voltage of the 12AV6 is nearly zero while all other voltages are correct, which component would you suspect to be bad?

14. If signal tracing this radio when there is no audio output reveals audio to be present at the plate of the 12AV6, but no audio is present at the control grid of the 50C5, which component is defective?

15. If the radio has a tunable hum what trouble would you expect to find in checking the radio?

16. All voltages in the radio are found to be normal while the sensitivity of the radio is very low. What trouble would you expect to find and what would you do to restore the radio to full sensitivity?

17. Describe the steps taken in question 16 to restore the radio to full sensitivity.

18. What is the function of A5?

19. If a signal of a radio station transmitting a signal of 860 KHz is tuned in, what is the frequency of the oscillator signal?

20. What effect does C4 have on the audio quality of the output?

21. What should the control grid to cathode voltage of the 50C5 be?

22. What is the function of R5?

23. What is the function of R8?

24. What is the function of C1?

25. If R9 is burned, R8 is undamaged, which component is most likely to have caused R9 to be damaged?

Answer Key to Quinmester Post-Test

Part-One

1. b
2. c
3. c
4. b
5. d
6. b
7. c
8. d
9. d
10. d
11. c
12. d
13. d
14. b
15. c
16. c
17. d
18. a
19. d
20. a
21. c
22. b
23. c
24. b
25. c
26. c
27. b
28. b
29. b
30. d
31. a
32. d
33. a
34. d
35. c
36. c
37. d
38. d
39. c
40. c
41. c
42. d
43. d
44. d
45. c
46. c
47. d
48. d
49. b
50. d

Figure 2-2 (B)

1. R2 slows down the discharge of C1, smoothing out the ripple.
2. 150 working voltage, D.C.
3. To isolate the chassis from B-, which is at line potential and hazardous if connected directly to the chassis.
4. Approximately 95 volts.
5. There would be no IF signal due to lack of oscillator signal to mix with the RF signal of a station. 12BE6 could not amplify due to open cathode circuit.
6. A small positive voltage due to lack of oscillator signal at grid.
7. The IF transformer, due to an open primary winding.
8. C5 would be shorted, thereby blowing out heater between terminals 4 and 6.
9. V1 heater is open
10. The 5000 mmf capacitor which is part of the audio couplate is shorted, thereby placing a positive voltage on the 50C5 grid, causing plate current to saturate and audio distortion.
11. Seondary winding of IF transformer I4 is open.
12. C4 is shorted thereby placing full B+ voltage on R7 and producing an excessive current flow through the resistor, making it hot.
13. 470K plate resistor nearly open.
14. 5000 mmf coupling capacitor open.
15. Heater to cathode short in 12BE6 or 12BA6.
16. The radio is out of alignment. Aligning IF transformers and adjusting RF and oscillator trimmer capacitors.
17. Align IF transformers to prescribed IF frequency, using signal generator and AC meter. First aligning output IF transformer then input IF transformer and adjusting trimmer capacitors at high end of band.

18. A5 is trimmer adjustment to oscillator capacitor.

19. 1315 KHz when IF frequency is 455 KHz.

20. C4 bypasses higher frequencies of audio, thereby causing audio to seem to have more bass.

21. 5.5 volts by virtue of the voltage drop across the cathode resistor.

22. R5 filters the AVC voltage.

23. R8 slows down discharge of the filter capacitor and smooths out ripple.

24. C1 is the filter capacitor which is used to smooth out the 60 cycle pulses so that only a small ripple voltage will be present on the DC voltage output of the power supply.

25. C1A, which would draw excessive current through R9, since R8 is undamaged there is no other possibility.